Guest-editorial

Special issue: Real-Time and Embedded Computing Systems

Seongsoo Hong
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Because of the technology convergence in computer, consumer electronics, and communication fields in the last decade, embedded computing has rapidly emerged as an important computing discipline. Currently, demands from a variety of embedded systems applications are continuously increasing and the interest in embedded computing technologies is growing very rapidly all over the world. Thus, embedded computing deserves separate and dedicated journals that can accommodate the many original technological contributions in this area.

Embedded computing differs from general purpose computing in the sense that embedded systems possess unique constraints for hardware resources, electronic power consumption, and communication bandwidth that are not frequently found in general purpose computing. In spite of these constraints, their usage is extremely diversified ranging from small personal handheld devices to complex smart vehicles. Thus, embedded systems design often leads to complicated design analysis and optimization, and costly implementation tuning. This in turn poses a great deal of challenges to embedded system theory and practice. This inaugural special issue of the *Journal of Embedded Computing* was prompted by the importance of real-time and embedded systems design technologies. Eight outstanding papers were selected from the ninth International Conference on Real-Time and Embedded Computing Systems and Applications (RTCSA 2003) held in February, 2003 and one paper was invited. The papers in this issue cover a variety of subjects addressing different aspects of embedded computing. They can be categorized as follows.

- Embedded software design methodologies and formal analysis
- Schedulability-aware embedded system design
- Low power and constraint-based system design
- Ubiquitous computing
- Embedded operating system architecture

In "A Class-based Approach to the Composition of Real-Time Software Components," authors Wang and Mok present a framework for composing independent components in an open environment. While a complex embedded real-time system may consist of multiple application components each with its own timeliness requirements, it is extremely difficult to support temporal composability in practice. The proposed framework applies a workload classification scheme to guarantee that the supply of shared resources always meets real-time constraints for on-budget workloads.

It is widely known that crosscutting concerns in software hinders encapsulation and component-based software development. To address this problem, aspect-oriented software development has been proposed in the object-oriented programming language community. In "Aspects and Components in Real-Time System Development: Towards Reconfigurable and Reusable Software," Tesanovic, Nystrom, Hansson, and Norstrom present a real-time aspectual component model that supports timing constraints, space and resource management constraints, and composability.

In designing embedded real-time systems, it is often of utmost importance to verify or validate the design at various stages of development. In "Symbolic Simulation of Industrial Real-Time and Embedded Systems

– Experiments with the Bluetooth Baseband Communication Protocol," Wang, Huang, and Yu present the design of a symbolic simulation function for dense-time concurrent systems and its implementation in their model-checker/simulator RED 4.0. They represent and manipulate state-spaces as logic predicates to encode a dense amount of traces in traditional simulation into one symbolic trace.

As embedded systems applications are more commonly deployed in an open environment such as the Internet, real-time guarantees for aperiodic requests become an important aspect in embedded system design. In "Deterministic and Statistical Admission Control for QoS-Aware Embedded Systems," authors Park, Ryu, and Hong present admission control tests using utilization demands to handle a mix of periodic and aperiodic tasks. They also present statistical admission control schemes using effective execution time to handle tasks with stochastic execution times. In "Comparative Analysis of Aperiodic Server Approaches for Real-Time Garbage Collection," Park, Kim, and Shin present a comparative analysis of deferrable and sporadic servers to exploit in implementing a real-time garbage collector.

Two papers address constraint-based embedded system design. In "Implementing a QoS-Aware MPEG-4 Video System for Embedded Computing," Ng and Hui present an encoding scheme using an object-based media with arbitrary-shaped and object-based QoS coding. It enables their video system to discard less important objects within a video stream when the network is congested. In "Bounded Energy Allocation and Scheduling for Real-Time Embedded Systems," authors Doh, Kim, Lee, and Krishina present an energy sharing model that allocates an energy budget among hard and soft real-time tasks, and a dynamic scheduling scheme to reduce energy consumption by switching between two scheduling policies and utilizing an explicit pattern of event occurrences.

In "Zero-Stop Authentication System for Sensor-based Embedded Real-Time Applications," authors Matsumiya, Aoki, Murase, and Tokuda present an intriguing application of sensor networks for ubiquitous computing. They propose a "Zero-stop Authentication" model and system that realizes automatic, real-time authentication in the physical world. Finally, in "Resource Management Architecture for Future Information Appliances," Oikawa and Nakajima present a CPU resource management architecture for information appliances. In this architecture, an embedded system may have multiple kernels by way of virtualized operating systems that run on a host operating system. To support time sensitive applications, they incorporate CPU resource reservation mechanisms in both virtualized and host operating systems.

Seongsoo Hong
Guest Editor
E-mail: sshong@redwood.snu.ac.kr